International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN(P): 2249-6890; ISSN(E): 2249-8001
Vol. 8, Issue 3, Jun 2018, 817-824

ROOMBOTS—MODULAR ROBOTS FOR ADAPTIVE FURNITURE

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ABSTRACT

Autonomous mobile robot navigation has generated a lot of interest among researchers in recent years. Herein, we outline the design of a four-tracked autonomous mobile robot with a main-controller regulated on the basis of a PIC microcontroller and Bluetooth. For navigation, the system includes a 3D accelerometer sensor and a Bluetooth module. The accelerometer helps improve navigation accuracy and performance to a very large extent in an autonomous mobile robot. Further, this accelerometer installed in the robot assists in detecting vibration, the presence of a slope, obstacle or any other object in its path, and for calculating the angle of the slope. The data collected by the accelerometer are sent to mobile through Bluetooth wireless communication.

This article presents the framework of the robot as building blocks of future furniture, and as the robot moves by self–reconfiguration, it is called roombots. Self-reconfiguration planning is a vital action that helps alter shape in an autonomous manner. For such planning, we put forward a new scheme that involves graph signature and graph edit distance. For establishing a hardware framework, an active connection system on the basis of physical latches has been proposed. In addition, task-dependent design limitations that might creep into the designing of future Roombot modules have been deliberated. Further, this study displays interest in adaptive furniture behavior, as well as online learning of locomotion patterns, for further applications of roombots.

***KEYWORDS:** Roombots, Bluetooth & Wireless Communication*

Received: Mar 06, 2018; **Accepted:** Apr 09, 2018; **Published:** Jun 04, 2018; **Paper Id.:** IJMPERDJUN201886

Original Article

INTRODUCTION

This study deals with an Android platform and its communication with robots with the help of a Bluetooth connection. It is predicted that the future would have working and living environments wherein people and new technologies would cohabit with ease. Such a progress has been mainly attributed to the development of concrete interaction modules with computers, universal computing, and augmented reality. Recently, a movement to integrate technologies in everyday artifacts has been noted, These include a range of tasks, for example, repetitive pick-and-place part handling, dangerous mass welding techniques, and accurate and detailed placement with the assembly of sensitive electronic components. Most of these robotic systems are under manual control with the help of a programmed “teach pendant.” A layperson may consider the teach pendant to be a complex device and be intimidated by it.

Therefore, this limits a ‘typical’ manufacturing plant employee from bringing about any modifications in the robot’s functionality. In addition, each robot manufacturer offers its own distinctive and exclusive programming interface, which deals with the design and evaluation of computer-augmented reality. User

interaction plays the main role in roomware projects, but users usually to not contribute to its design. Herein, we put forth a design for modular robots and its control strategy. Our designed roombots can be used as blocks of building, to move the furniture, self-reconfiguration, self-assembly, and self–repairs, contingent to user requirements.

Modular robots have been described as robots with multiple simple robotic modules that can attach and detach.

Bio-Inspired Robotics Group

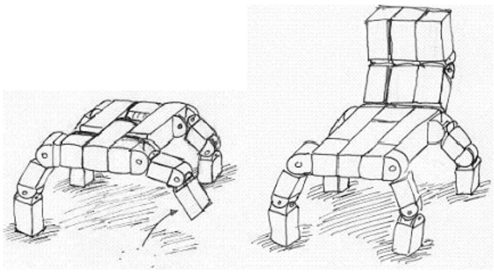

Figure 1: Sketches for a Stool and a Chair

At first, when roombots were envisaged as groups, it was assumed that they would automatically connect to one another, thereby helping to create furniture of various forms, for example, chairs, stools, sofa and tables. The type of furniture generated was considered user dependent and as per their convenience.

Furniture created with roombots is capable of changing shape according to requirement (e.g. an stool becoming a chair, a set of chairs becoming a sofa), in addition to the movement to different locations using its actuated joints. Further, when not in use, the group of modules can fashion themselves into a static structure such as a wall or a box. Fig. 1 displays a few examples of such furniture. Motion using the actuated joints of a modular robot is an important criterion for the Roombots. For instance, a chair created by a quadruped robot should be capable of locomotion from point A to point B, and should possibly be able to climb and descend stairs as well. Currently, much focus has been given to research on the wireless communication of robots, which basically deals with effective navigation systems for mobile robots, their interaction modules across a busy environment and operation of a network infrastructure. A large interactive network is in the pipeline. However, our research deals with stationary robotic systems, as our study basically deals with establishing two-way communication to improve flexibility between the robotic arm and a mobile control device Our approach is unique as we present a more generic model for a robot, which can be applied without adapting them to the operations of a single robot. Roombot modules contain building blocks for crating adaptive furniture. They have been branded as self-reconfiguring modular robots, which can be further subdivided into smaller modular robots.

Roombots display lattice or chain-like features, and usually configure on their lattice while building furniture. However, when constructing adaptive furnitures such as beams and panels, roombots usually display chain-type characteristics. Hardware for such chain-like self-reconfiguring modular robots entails self-sufficient robot modules that display a low degree of freedom. Active connection systems are operated to provide connectivity between one module and another or with the environment. Design constraints are set for self-reconfiguring modular robots on the basis of their task requirement, more so for Roombot modules. The task requirement may be categorized as follows: (a) self-reconfiguration (b) locomotion and (c) usage.

It is essential that these robots be self-sufficient with regard to power supply, computation, sensors, communication and actuation.

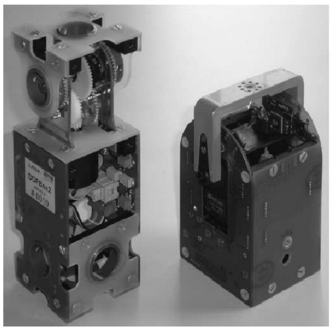

Figure 2

Figure 2 displays examples of two different modular robot types. These robots do not exhibit self-reconfiguration properties; on the left side is a DOF-box, and on the right side is yaMor. The furniture created by the robots are large static structures with the external load. These robots need to have an effective, user-oriented design, with an established human–robot interface (HRI). Emphasis has been placed on safety, comfort and robustness. We highlight the various features vital for the generation of significant roombots. This article is structured as follows. The next section provides a concise description of the extracted hardware design and its issues, such as the degree of freedom and the active connection mechanism; these aspects are dealt along with the first design for Roombot modules. In the following section highlights our self-reconfiguration plans. The fourth section proposes a mechanism for distributing locomotion control among the various assemblies of modular robots. The final concluding section summarizes with a description of future research. Because the latest module design for Roombots has been a recent development, Sections 3 and 4 refer to modules with YaMoR and Dof-box features. Self-reconfiguration planning has been illustrated using a simulation of the M-TRAN modules.

HARDWARE

The aim of the Roombots design was the construction of a novel modular robot platform that would be appropriate for building adaptive furniture on the principle of self-reconfiguration. Each Roombots module requires individual actuated joints, controller, and energy supply. Mechanical connectors permit speedy and solid attachment and detachment techniques between modules. The modules must have connector designs that provide the robots with enough sturdiness for supporting a person.

Available Hardware

Our modular robot models of the DOF box and yaMor lacked designs for an active connection mechanism. As shown in Figure 3, we implemented a functional connection mechanism that was based on physical latches and the existing features from the DOF box.

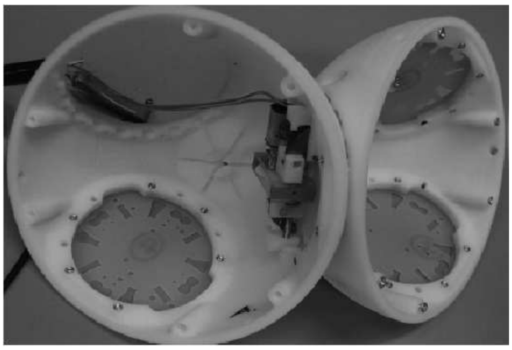

Figure 3

Figure 3 Active connection mechanism (middle) based on physical latches, which are included in 2 half-shells of the future Roombots modules. As the ACM is hermaphrodite in nature, a combination of passive and active ACMs is possible.

YaMoR displays sensing capabilities, with on-board computation using various platforms, on-board battery control, a gearbox scheme, motor-control patterns and Bluetooth-based communication (SNP). These active connection mechanisms can be implemented into the Roombot modules of the future. However, certain features continue to be a part of the system such as the (a) option for the axis of rotation/layers of translation, (b) the quantity of dof per module2 and (c) the characterization of lattice3 that accumulation build-up of modules creates. Depictions that vary from these three design constraints could provide a relatively fine mesh to sort all available modular robots.

Limiting the Design Choice

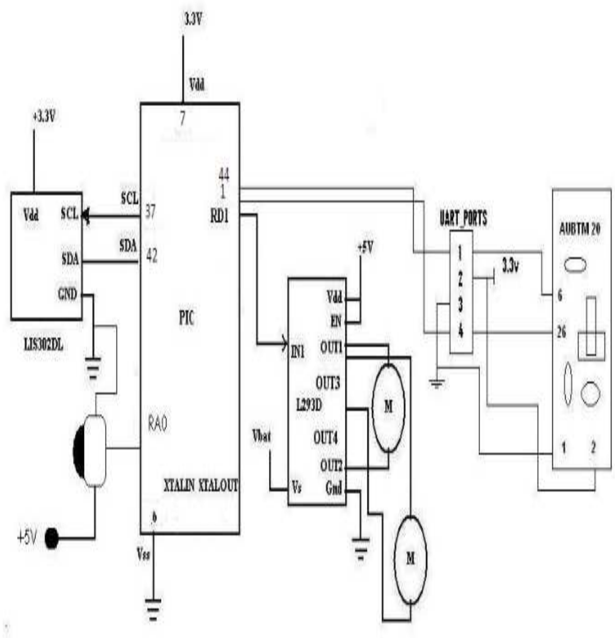

Figure 4: Circuit Diagram for Robotic Module

The module is made up of a microcontroller, MEMs sensor, motor driver, PIR sensor and power supply. The microcontroller is a 18F4480 model with five bidirectional ports, A, B, C, D and E. PORTB and PORTC are designed to drive higher loads, such as LEDs. All other ports are designed for small loads, normally indication only. PORTA pins

have TTL input levels and full CMOS output drivers. The TRISA register regulates the direction of the PORTA pins; this is so even when they are employed as analog inputs. The user must confirm whether the bits in the TRISA register are upheld prior to using them as analog inputs. PORTB is an 8-bit wide, bidirectional port. The corresponding Data Direction register is TRISB.

PORTC is also an 8-bit wide, bidirectional port. The corresponding Data Direction register is TRISC. PORTD is an 8-bit port with Schmitt Trigger input buffers. Each pin can be separately configured as an input or output. PORTE has the following three pins: RE0/RD/AN5, RE1/WR/AN6 and RE2/CS/AN7. These pins may be configured as inputs or outputs in an individual manner. A 12V rechargeable battery is used in the robotic module for movement.

Roombots Design

Mobile robot wireless networks offer networking organization to assist in the quality of service (QOS) needs (bandwidth, latency and reliability) involved in robot communications. They must aid in speedy reconfiguration of token ring Mobility management (mobile IP, AODV), service-level agreement (SLA) management, and QOS (mobile Internet Protocol). Mobile robot networking thus has a layered structure. It has transport, network, data link, and physical components.

Cooperative multiple mobile robots must have efficient communication systems. These robotic communications are achieved via random access telecommunication among mobile robots. Experiments on robotic communication have usually deployed wireless LAN or infrared sensor systems. However, whether these systems can cater to a large number of robots simultaneously is yet to be confirmed. We propose an adapted cellular system that would have applications for wide-range robotic communication. The communication service area is controlled by the positions of BS.

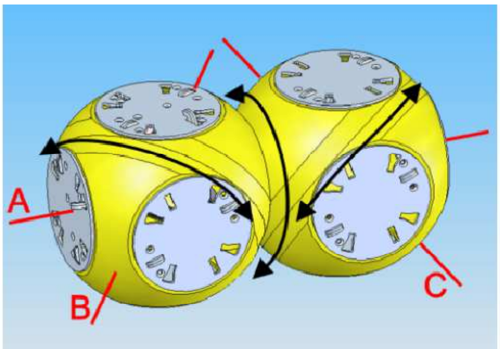

Figure 5

CAD sketch of one Roombots module. Axes of rotation are represented in red (A, B and C), and the dof is indicated with black arrows. All dof are 360°.

SELF-RECONFIGURATION PLANNING

Modular robotics is a novel area of research that has much to offer with its numerous potential applications. The significance of these robots lies in their reconfiguration ability, which enables them to adapt to their environment, implement tasks with improved efficiency, self-repair and self-replicate. Self-reconfiguration in modular robotics is, nevertheless, a difficult task. Interesting details regarding the locomotion, self-reconfiguration and self-organization algorithms of modular robots are available in the literature, which we have put forth. Thereafter, we have outlined the

characteristics of a new generation of modular robots designed by the Biologically Inspired Robotics Group labelled Roombots. Further, a new decentralized framework has been outlined. This framework permits movement and self-reconfiguration with near real-time competitive performances. Modular robots usually can be categorized into two different types: lattice-type and chain-type. Lattice-type modular robots can move only through self-reconfiguration. Power joints that permit movement in one specific configuration are absent. Continuous reconfiguration is mandatory for their movement. Chain-type modular robots can also reconfigure, but have the added benefit of movement in one configuration without the need for reconfiguring. Usually, reconfiguration is not used for movement, but for adaptation to new tasks or shifting environments. This study basically deals with chain-type robots, as Roombots fall into this category. Movements of these robots are more complicated than lattice-type robots, and they might be incapable of lifting big chains of modules, with self-collision being a typical part of their movements.

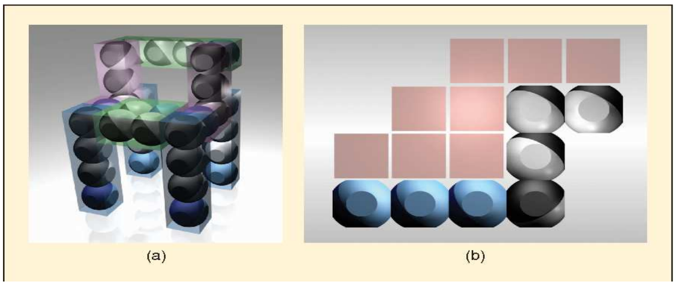

Figure 6: Graph Representation of a Stool and a Chair

DISTRIBUTED LOCOMOTION CONTROL

Fundamental to the DCS model was the addition of control function blocks. Function blocks progressed from initial, more basic DDC concepts of "Table Driven" software. One of the primary features of object-oriented software involved function blocks that were self-contained "blocks" of code imitating analog hardware control elements and performing tasks that were elemental to process control, such as the implementation of PID algorithms. Function blocks continue to perform as the principal control method for DCS suppliers. Currently, these blocks are supported by strategic technologies such as Foundation Field bus.

CONCLUSIONS AND FUTURE WORK

This study has proposed an independent robot with an operating system that involves an independent application interface. In addition, significant two-way communication has been established between the Android controller and the robot. Such a communication would enable even a layperson to interact with and regulate the functionality of a manufacturing process that is dependent on articulated robotic systems. Such an application would assuredly lessen human effort and prevent many accidents. Besides, this robot can be employed in various other industrial functions.

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